UNITED STATES DISTRICT COURT
NORTHERN DISTRICT OF TEXAS
DALLAS DIVISION

UNIVERSITY OF SOUTH FLORIDA
RESEARCH FOUNDATION, INC.,

Plaintiff,

Case No. 3:18-CV-0250-K

vs.

BRIT SYSTEMS, INC.,

Defendant.
_____/

USFRF'S RESPONSIVE CLAIM CONSTRUCTION BRIEF

APPENDIX[1]

Ex. No.	DOCUMENT	PAGE
M	Reply Declaration of Joseph C. McAlexander III Regarding Claim Construction of U.S. Patent No. 6,630,937	APP. 362-394
N	The American Heritage Dictionary Definitions of Correspond and Corresponding	APP. 395-398
O	Oxford Dictionary Definition of Corresponding	APP. 399-400

Dated: October 1, 2018

Respectfully Submitted,

/s/ Steven A. Caloiaro

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[1] The Appendix continues the exhibit numbers and Bates from Plaintiff's Opening *Markman* Claim Construction Brief Appendix. (ECF 137).

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CERTIFICATE OF SERVICE

I hereby certify that a true and correct copy of the foregoing was filed electronically and served on all counsel of record on October 1, 2018 via the Court's ECF system.

Steven A. Caloiaro
Steven A. Caloiaro

EXHIBIT M

REPLY DECLARATION OF JOSEPH C. McALEXANDER III REGARDING CLAIM CONSTRUCTION OF U.S. PATENT NUMBER 6,630,937

UNIVERSITY OF SOUTH FLORIDA RESEARCH FOUNDATION, INC.

v.

BRIT SYSTEMS, INC.

IN THE UNITED STATES DISTRICT COURT FOR THE NORTHERN DISTRICT OF TEXAS DALLAS DIVISION

(Civil Action No. 3:18-CV-00250-K)

October 01, 2018

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IN THE UNITED STATES DISTRICT COURT
FOR THE NORTHERN DISTRICT OF TEXAS
DALLAS DIVISION

UNIVERSITY OF SOUTH FLORIDA RESEARCH FOUNDATION, INC., **Plaintiff,** **v.** **BRIT SYSTEMS, INC.,** **Defendant.**	**Case No. 3:18-CV-00250-K** **JURY TRIAL DEMANDED**

REPLY DECLARATION OF JOSEPH C. McALEXANDER III
REGARDING CLAIM CONSTRUCTION OF
U.S. PATENT NUMBER 6,630,937

1 INTRODUCTION

1. I have been retained by Dickinson Wright, PLLC, counsel for the Plaintiff, University of South Florida Research Foundation (hereinafter referred to as "USFRF" or "Plaintiff"), to respond to certain opinions and positions taken by BRIT Systems, Inc. (hereinafter referred to as "BRIT") in its construction brief entitled "DEFENDANT BRIT SYSTEMS' OPENING CLAIM CONSTRUCTION BRIEF," FILED 09/17/18 (hereinafter referred to as "BRIT's Construction Brief"). I previously submitted my opening declaration entitled "DECLARATION OF JOSEPH C. McALEXANDER III REGARDING CLAIM

CONSTRUCTION OF U.S. PATENT NUMBER 6,630,937," filed 9/17/18, and incorporate that declaration by reference in its entirety.

2. As stated in that opening declaration, I viewed the claims in the 6,630,937 Patent (hereinafter referred to as the '937 Patent) from the perspective of a person of ordinary skill in the art to which the claimed inventions were directed. And based on that view toward the claims, I represented how a person of ordinary skill in the art would define or interpret certain words and phrases used in the claims.

3. This Declaration contains my responses directed to BRIT's positions on the following '937 Patent claim terms as being indefinite, based in part on an alleged lack of, or sufficiency of, specification support, as understood by a person of ordinary skill in the art at the time of the invention (hereinafter referred to as a "POSITA"):

(1) **algorithm disclosure**, as associated with the means plus function claim terms, *e.g.*,[1]

> "means for transforming the digitized mammogram data into a plurality of varying-resolution forms, each form having different greyscale values"

(2) **digital vs. digitized**, as associated with the claim terms[2]

> "digitized [mammogram]\[mammography image],"
>
> "greyscale/grayscale values,"
>
> "digitized medical image,"
>
> "system for analyzing," and
>
> "the digitized mammogram data having greyscale values corresponding to optical densities of the film mammogram image"

[1] BRIT's Construction Brief, 1, 19-34. BRIT's position is that no algorithms are disclosed in the '937 Patent to provide sufficient structure to support any of the claims at issue in this case. This is expressly introduced at p. 1 of the BRIT Construction Brief – "it was drafted without any disclosure of the algorithms the workstation uses to carry out these specific computer-implemented functions."
[2] *Id.*, 6-7, 8.-9, 12-13, 13-14, 14-15.

(3) **illumination characteristics**, as associated with the claim terms[3]

> "to display a mammogram image in a different form in each window with grayscale values that, along with the illumination characteristics of said monitor, appears to a user as a mammogram in each window under a predetermined illumination state," and
>
> "said processor . . . being responsive to a signal from said input device to transfer digitized image data from said electronic storage medium to said monitor in a way that causes the monitor to produce a display having a plurality of windows and to display a mammogram image in a different form in each window with grayscale values that, along with the illumination characteristics of said monitor, appears to a user as a mammogram in each window under a predetermined illumination state"

4. I specifically reserve the right to formulate and offer additional or supplemental opinions based on any future court rulings, agreements between the parties, or additional evidence submitted by either party either prior to or at the claim construction hearing or thereafter, to the extent permitted by the Court.

5. The opinions I formed are covered in detail in Section 7. The bases for those opinions are defined in Section 6. And the references I have reviewed and considered are addressed in Section 5.

6. I anticipate being called to provide expert testimony before the District Court regarding my opinions formed resulting from my review of the '937 Patent. I further expect to be called to provide a tutorial to the District Court regarding the general field of technology to which '937 Patent is directed.

2 QUALIFICATIONS

7. Refer to Section 2 of my opening declaration.

[3] *Id.*, 10-12, 22-25.

3 OTHER CASES

8. Refer to Section 3 of my opening declaration.

4 COMPENSATION

9. Refer to Section 4 of my opening declaration.

5 REVIEW AND USE OF DOCUMENTS, DEPOSITIONS, AND OTHER MATERIALS

10. I have reviewed and considered, in the preparation of this declaration, documents identified in Attachment A to my opening declaration, including the above identified patent, the prosecution history associated with that patent, the parent patent U.S. Patent Number 5,987,094 and the prosecution histories of the "parent" patent applications, and the references cited to and by the U.S. Patent and Trademark Office ("USPTO") during prosecution. I have also reviewed BRIT's Construction Brief and "PLAINTIFF'S OPENING MARKMAN AND CONSTRUCTION BRIEF, filed 9/17/18 (hereinafter Plaintiff's Construction Brief"). Additionally, I have reviewed information generally available to, and relied upon by, persons of ordinary skill in the art including technical dictionaries, technical reference materials, and well-known principles of communications protocol, transmission, and control. I also relied on my experience in the electronics, integrated circuit, and digital imaging industries in formulating my opinions.

11. I anticipate using some of the above referenced documents and information, or other information and material that may be produced during the course of this proceeding, as well as representative charts, physical exhibits, and models that will be based on those documents, information, and material, to support and to explain my testimony before the District Court

regarding claim construction based on the definition of claim words and phrases from the perspective of a person of ordinary skill in the art to which the inventions are directed.

6 BASIS OF OPINIONS FORMED

12. Refer to Section 6 of my opening declaration.

7 OPINIONS TO BE EXPRESSED

7.1 The Person of Ordinary Skill in the Art ("POSITA")

13. In my opinion, a person of ordinary skill in the art would have had a technical degree in electronics (or the equivalent) with three or more years of technical experience, or a Bachelor of Science degree in electrical engineering (or the equivalent) with two or more years of technical experience, or the equivalent education and work experience. A person with a higher level of education related to the technology may require a lesser level of experience.

7.2 Claim Construction Relevant to the '937 Patent

14. I included in my opening declaration Table 1 (Claim Construction Positions for the Terms Disputed as Subject to 35 USC §112 ¶6) and Table 2 (Claim Construction Positions for the Terms Not Subject to 35 USC §112 ¶6) that set forth the claim construction positions of both the Plaintiff and the Defendant. The representations made in my opening declaration remain unchanged and are incorporated by reference in their entirely.

7.3 Response to BRIT's Positions

7.3.1 The '937 Patent Specification Provides Sufficient Algorithm Disclosure[4]

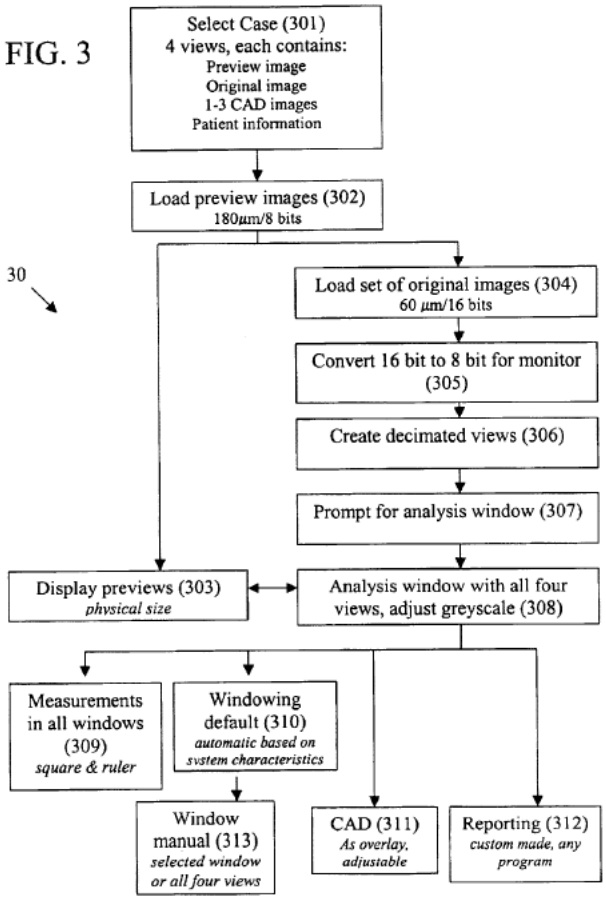
15. Presented in Table 1 of my opening declaration are the specification cites that identify the corresponding structure for each of the claimed functions. Supporting those respective

[4] Referring to Table 1, No. 1; *See also* my opening declaration at Section 7.5.3.1.

corresponding structures are cites that present the supporting algorithms expressing detail about how the respective structure performs its claimed function; and that detail is more than what is expressly stated in the claimed function.

16. BRIT, in the BRIT Construction Brief, asserts that the specification fails to provide the necessary algorithm support for the claims at issue in this case.[5] As discussed below, I disagree with this position and provide evidence that conclusively rebuts this position.

17. Figure 3 of the '937 Patent, reproduced below, is one way of expressing an algorithm, representing the algorithm as a flow chart.



[5] *See, e.g.*, BRIT Construction Brief at 1.

Defendant asserts that the flow chart of Fig. 3 is not an algorithm but is only a "flow chart."[6] That position, in my opinion, is erroneous as a flow chart is one of several ways known to and used by a POSITA to express an algorithm that provides sufficient detail to teach a POSITA how to implement the claimed structure to perform the recited function.

18. Flow charts to a POSITA are visual ways of expressing algorithms because they show or contain a series of steps to be taken in a process. Not only does Figure 3, as a whole, show an algorithm, but it comprises several algorithms. For example, steps 304-308 show one algorithm where digital images are converted and then decimated in order to provide images of a size to fit a monitor. Steps 307 and 308 disclose another algorithm where the user secures analysis windows having different views on the monitor and then adjusts the grey scale of one or more of them. Similar algorithms exist in other combinations of steps in Figure 3. And the written description text of the '937 Patent that describes these steps further elucidates the expression of the corresponding algorithm.

19. Further, additional algorithms exist in the written portion of the specification associated with Figure 3, either by itself or in combination with one of the other figures. In the discussion in Column 5 of the Patent, for example, the various steps that can be taken by the observer (*i.e.*, radiologist) to analyze the digital images and to manipulate their greyscales is an algorithm.

20. In particular, Figure 3 of the '937 Patent presents a flowchart version of algorithm 30, "showing the sequence of steps in implementing the workstation interface."[7] Algorithm 30 includes block 305, "Convert 16 bit to 8 bit for monitor." A POSITA would have understood that, at the time of the inventions of the '937 Patent, "Convert 16 bit to 8 bit for monitor" meant changing

[6] *Id.*, 19-20.
[7] '937 Patent at 2:48-49.

the display characteristics of an original image having, for each pixel in the original image, 65,536 greyscale levels or values into a converted image having, for each pixel in the converted image, 256 greyscale levels or values.[8]

21. The sufficient structure for this is included in the specification by reference to an image library. A library is a collection of non-volatile resources used by computer programs, often for software development. These may include configuration data, documentation, help data, message templates, pre-written code and subroutines, classes, values or type specifications. An image library adds support for opening, manipulating, and saving many different image file formats.

22. While there are many types of image libraries, the '937 Patent references or discloses the XIL image library. Specifically, XIL is a language designed and used by Sun Microsystems Corp., the software developer. The XIL library supports four data types: 1-bit data, 8-bit unsigned data, 16-bit signed data, and single-precision IEEE floating point data. An image's data type is established when a person creates the image by passing to the xil_create() function one of the following enumeration constants: XIL_BIT, XIL_BYTE, XIL_SHORT, or XIL_FLOAT. These enumerators are of type XilDataType. XIL language was well-known to a POSITA.

23. Thus, a POSITA would have understood "how" to implement the claimed function of "transforming the digitized mammogram data into a plurality of varying-resolution forms, each form having different greyscale values"[9] based upon its common understanding of an image library.[10]

[8] A bit can have one of two states, either a 1 or 0. 2 (number of states) raised to the 16th power = 65,536 values; 2 (number of states) raised to the 8th power = 256 values.
[9] Corresponding conversions from 16-bit to 8-bit are equally applicable to direct digital conversion.
[10] Corresponding conversions from 16-bit to 8-bit are equally applicable to direct digital conversion.

24. A POSITA would have also understood, from the '937 Patent embodiment description, that the software implemented to achieve the conversion would comprehend interfacing to a user such that the user would be able to select the desired view presented on the monitor by using, *e.g.*, a pointing device, such as a mouse.[11]

25. A POSITA further would have understood that the "for monitor" language, associated with block 305 of Fig. 3, meant that the original image was being converted (transformed) to match the display characteristics of the monitor (*e.g.*, the DR-110 monitors disclosed at 4:21-24). A POSITA would have understood that the recitation of "Convert 16 bit to 8 bit for monitor" in block 305 of Fig. 3 conveyed sufficient structure to understand the purpose and function of block 305 and, importantly, how that function was to be implemented. That is, a POSITA would have understood that block 305 recites sufficient algorithm structure (Convert 16 bit to 8 bit for monitor) to perform the function "transforming the digitized mammogram data into a plurality of varying-resolution forms, each form having different greyscale values." A POSITA would have understood that a more detailed algorithm, such as in the form of explicit computer code, need not be recited or referenced in block 305 because a POSITA would have understood that coding (software programming) was available to execute the algorithm in the context of the inventions of the '937 Patent.

[11] '937 Patent at 4:64 – 5:32.

26. XIL specifically provides the corresponding code to change an image to an 8-bit gray scale. The code display used to perform this color-space conversion is as follows:

```
XilImage image              = NULL;
XilImage bit_image          = NULL;
...
XilColorspace rgb_cspace;
XilColorspace ylinear_cspace;
...
bit_image = xil_create(state, width, height, 1, XIL_BYTE);
...
rgb_cspace = xil_colorspace_get_by_name(state,"rgblinear");
xil_set_colorspace(image, rgb_cspace);
ylinear_cspace = xil_colorspace_get_by_name(state, "ylinear");
xil_set_colorspace(bit_image, ylinear_cspace);
xil_color_convert(image, bit_image);
...
```

https://docs.oracle.com/cd/E19504-01/802-5863/802-5863.pdf.[12]

27. Before you can display your image in an 8-bit window, you must case the 16-bit values in the source image to 8-bit values, as shown in this code fragment.

```
XilImage short_image, byte_image;
unsigned int width, height, nbands; /* Dimensions of images */

byte_image = xil_create(state, width, height, nbands,
    XIL_BYTE);
xil_cast(short_image, byte_image);
```

[12] The XIL™ Imaging Library provides a set of key functions for the fields of image processing and digital video. XIL™ Programmer's Guide explains how to use these functions in developing application programming interfaces (APIs) and applications. The entire documents is in excess of 700 pages, so I have instead attached the representative sections I have discussed in by declaration as Exhibit A.

28. XIL also provides structure and function to case the value of the rescaled image:

> **3. Cast the values in the rescaled image to be of type `XIL_BYTE`.**
> Although you have rescaled your image so that its values fall in the range 0 to 255, those values are still 16-bit signed values. Before copying your image to the display, you must use the `xil_cast()` function to create an `XIL_BYTE` version of the image. For more information about `xil_cast()`, see "Casting an Image From One Data Type to Another," below.
>
> Here's another case in which you may need to rescale an image before displaying it. Suppose you want to display an 8-bit grayscale image in an 8-bit `GrayScale` window, but you do not want to use the currently installed X colormap in displaying it. You want to create a new virtual X colormap, store a grayscale ramp in that colormap, and have it installed when your application is active. If you write values to all 256 color cells in the virtual colormap, you're almost certainly going to see colormap flashing when the colormap is installed, so you may decide not to write values to the first 16 color cells—to write all the values needed to display your image in color cells 17 through 255. This strategy requires that you rescale the values in your image so that they fall in the range 17 to 255.

29. Algorithm 30 also includes block 306, "Create decimated views." A POSITA would have understood that, at the time of the inventions of the '937 Patent, "create decimated views" referred to reducing the number of pixels in a digital image. By reducing the number of pixels in an image, this decimating step, *e.g.*, would make the entire image displayable on a monitor display or in a window of the monitor display.[13]

30. A POSITA would have known, at the time of the inventions of the '937 Patent, that the description provided in block 306 of Figure 3 disclosed sufficient algorithm structure in the form of decimation to perform the transforming function to achieve a plurality of varying-resolution forms based upon the degree of decimation. A POSITA further would have known that a number of possible instructions were available to perform the decimation and that explicit computer code need not be described in the specification, and in fact, was unnecessary for the

[13] '937 Patent, Figure 4, windows 41 and 42, showing decimated images.

POSITA to understand what the necessary structure was and how to use the structure to perform the function based upon the algorithm disclosed in the '937 patent. Thus, the POSITA would have understood how to implement a desired decimating code, as described by the disclosed algorithm, in the context of the inventions of the '937 Patent.

31. Finally, the POSITA would have understood that algorithm 30, blocks 305 and 306, correspond to "means for transforming the digitized mammogram data into a plurality of varying resolution forms, each form having different greyscale values" and that blocks 305 and 306 conveyed sufficient structure to the POSITA to allow the POSITA to implement the claimed "transforming" function without the need to recite a known, specific code based on the algorithm in either block 305 or block 306.

32. I conducted a similar analysis for each of the claim terms that may require specification algorithm support. My findings are the same, using the same analysis process. Sufficient specification support is provided for each of the claim terms.

33. Focusing on the varying resolution limitation, the '937 Patent details the creation of the decimated views as an algorithmic step (Fig. 3, block 306 of the Patent) with an accompanied illustration (Fig. 4, 41 and 42). The explicit step of subsampling the image into varying resolutions would have been known to POSITA at the time of the invention, an example of which can be found in the XIL library:[14]

[14] *See* figure reproduced from the XIL manual, 233.

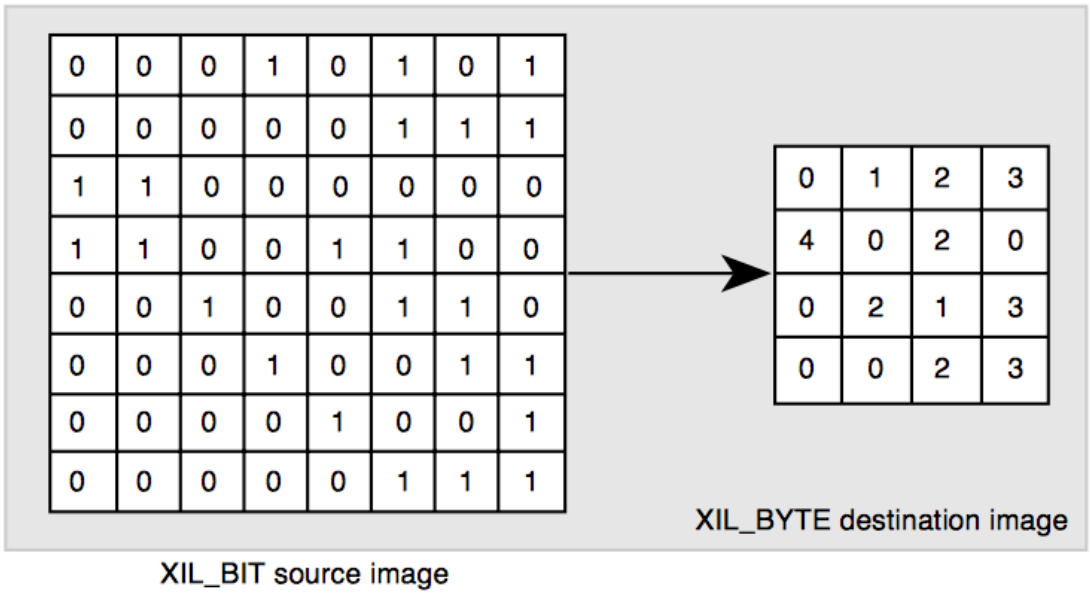


Figure 12-5 Subsampling Bit Images

7.3.2 Digital vs. Digitized[15]

34. Plaintiff's proposed construction of digitized medical images or digitized mammography images reflects how a POSITA would have understood the claim limitations. Specifically, a POSITA would have understood that digitizing is the process of converting (digitizing) captured non-digital (*e.g.*, analog or continuous) data to form a digital image regardless of the initial source of the non-digital data.

35. BRIT's Construction Brief mischaracterizes Plaintiff's use of the words "digital" and "digitized." A POSITA understands that digitization is the act of digitizing. This is confirmed by the dictionary definitions cited by BRIT in its opening brief. Digitizing captured data produces a digital output, *e.g.*, a digital image. It is, therefore, entirely proper to refer to "digitized

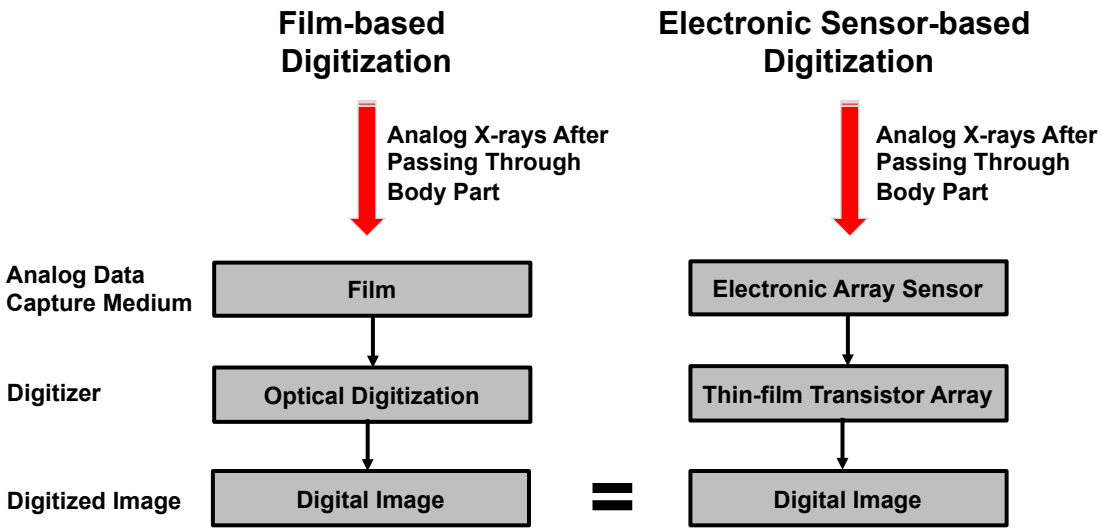
[15] Referring to Table 2, Nos. 2, 3, 9, 10, and 11.

mammogram / digitized mammography images" as "digital images" since a "digitized" image is one which has been created by a digitizing process, the output of which is a digital image.

36. At the time of the inventions of the '937 Patent and the '094 Patent, and for many years thereafter, most digital medical images were digitized from physical data captured on x-ray film. X-ray film was a commonly-used analog data capture medium. However, as a result of pioneering inventions, including those of the '937 Patent, the imaging community, including medical, shifted primarily to the use of digital images (*e.g.*, digital mammograms) digitized from data captured by electronic sensors, where the electronic sensors replaced x-ray film as the data capture medium.

37. Currently, most digital mammography images are digitized not from x-ray film but rather from electronic sensors (sometimes referred to as "native" digital imagery or "direct" digital imagery). That is, nearly all current digital imaging technologies involve the capture of image data first into a non-digital form. The image data then are digitized into discrete, pixel-by-pixel data-points to form a digital image.

38. A simplified diagram is provided below to illustrate the correlation between digitization from film and digitization from electronic sensors.



39. As the above diagram illustrates, both digitization processes use data capture mediums and digitizers to produce a digital image from the corresponding data source. The differences lie in the structural implementation of the data capture mediums and in the digitizers.

40. A POSITA would have understood that, at the time of the inventions, the '937 Patent claims were directed to a user interface with tools that allowed the display and manipulation of digital images. The POSITA further would have understood that the source of the digital images and the structures and methods for producing the digital images were not relevant to the '937 Patent claims. It is clear that a POSITA would have understood that the inventions disclosed in the '937 Patent would not have been limited to digitized film images. Instead, a POSITA would have understood that the inventions of the '937 Patent apply to all digital images, regardless of the mechanism used for x-ray data capture and regardless of the structure and method used to digitize the captured x-ray data to form the digital images.

7.3.3 Illumination Characteristics[16]

41. BRIT contends in the BRIT Construction Brief that the use of the term "illumination characteristics" in claim 2 of the '937 Patent renders that claim indefinite, stating "The '937 Patent provides no explanation as to what 'illumination characteristics' of a monitor are, nor how such characteristics should go "along with" grayscale values of an image to affect how a mammogram appears in different windows under a predetermined illumination state."[17] I disagree.

42. The specification is clear on this point. The '937 Patent addresses illumination characteristics in its discussion of display monitors:[18]

> The characteristics of display monitors 14,16 are important to proper implementation of the present invention. Screen film mammography is interpreted on viewboxes with an average luminance of about 3000 nit (880 ft-L),[10] which gives excellent back-lighting to x-ray films. In contrast, the typical color monitor provided with the Sun workstations is only about 30 ft-L. The maximum display resolution of 1280x1024 pixels with standard monitors is not enough for x-ray films digitized at 30 um/pixel, which are in the range of 3000×5000 pixels. Dome Imaging Systems Inc. (Waltham, Mass.), manufactures 5-megapixel display cards for the Sun that are capable of driving high-resolution grayscale monitors. The monitors 14, 16 chosen are the DR-110 from Data Ray Corp (Westminister, Colo.). These are 2048x2560 pixels at 74 Hz, with a luminance of 120 ft-L and 30 c. A dual-monitor setup was selected (FIGS. 1 and 2) to accommodate simultaneous multiple image display.
>
> [10] A. Haus, J. Gray, and T. Daly, "Evaluation of mammographic viewbox luminance, illuminance, and color," Med. Phys. 2003), pp. 819–21, 1993.

43. BRIT agrees that the claimed illumination characteristics applies to the monitor. Referring to the above quote from the '937 Patent, those characteristics are important to the invention implementation. The '937 Patent specification contrasts the luminance of viewboxes

[16] Referring to Table 1, No. 4 and Table 2, No. 8; *See also* my opening declaration at 7.5.3.4.
[17] *See* BRIT's Construction Brief at 11.
[18] '937 Patent, 4:11-26.

used to view x-ray film to that of a color monitor associated with a workstation. Also represented by the '937 Patent is a Dome Imaging Systems monitor system capable of "driving high-resolution grayscale monitors." The '937 Patent further identifies the pixel count, the luminance and the transmissivity of this monitor.

44. A POSITA would have understood that the illumination characteristics of a monitor refers to the amount of luminance flux incident on the surface of a monitor and is readily known by a POSITA as such information is provided as part of a monitor's specification. Such luminosity is also well-correlated to human brightness perception. This term is well-understood to a POSITA and needs no further explanation in the '937 Patent.

8 EXHIBITS TO BE USED AS SUMMARY OF OR SUPPORT FOR OPINIONS

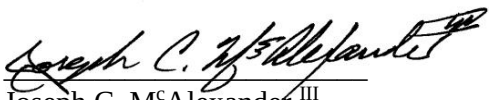
The following exhibits may be used as a summary of or support for my opinions:

1. The Patent-in-suit;
2. Prosecution History of the Patent-in-suit, including U.S. Patent Number 5,987,094;
3. Charts, diagrams or animations illustrating the subject matter of the Patent-in-suit and the structure and function of various embodiments of the inventions described in the Patent-in-suit;
4. Charts, diagrams or animations illustrating the configuration of prior art systems as they are used in typical applications;
5. All references in this declaration, in any other report or reports I provide in this lawsuit, and in the expert declarations and reports submitted by the Defendant; and
6. Charts, diagrams or animations associated with a tutorial.

9 CONCLUDING REMARKS

45. I understand that the parties may agree to definitions after the completion of this declaration that may differ from the definitions I have set forth. I may also amend or supplement my opinions upon seeing the declaration(s) and report(s) from the Defendant's expert(s) and/or the Defendant's claim construction briefing to account for issues that were not apparent when I prepared this declaration, as indicated above. If amendments or supplementation is necessary, I will do so in a timely manner. I understand that the final claim construction will be defined by the Court. I will abide by that decision when provided.

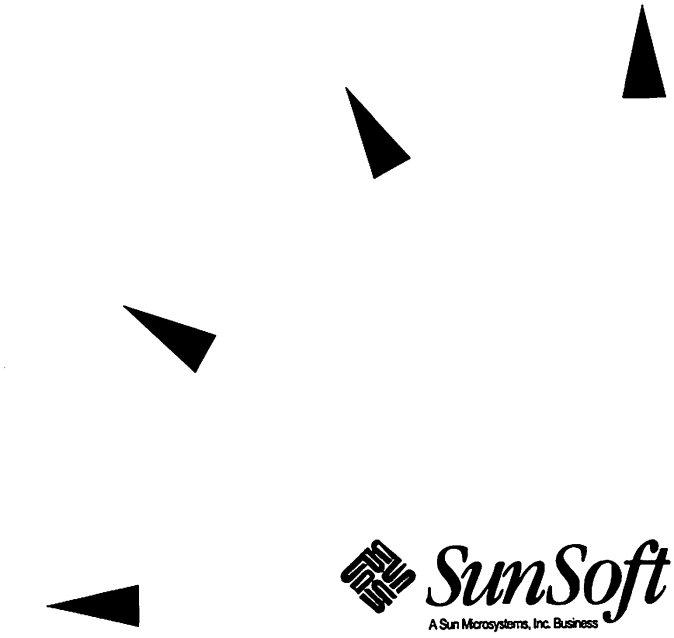
Dated: October 01, 2018



Joseph C. McAlexander III

EXHIBIT A

XIL™ Programmer's Guide



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SunSoft
A Sun Microsystems, Inc. Business

Preface

The XIL™ Imaging Library provides a set of key functions for the fields of image processing and digital video. This book explains how to use these functions in developing application programming interfaces (APIs) and applications.

Who Should Use This Book

The XIL library was designed to meet the needs of developers creating APIs and applications for a number of markets. These markets include:

- Markets that require digital video technology
- Commercial document imaging
- Technical document imaging
- Desktop publishing
- Color prepress
- Graphics arts
- Technical imaging

How This Book Is Organized

This book presents XIL in three parts. Chapters 1 through 8 explain how to create the framework for an XIL program and discuss such topics as input, output, and error handling. Chapters 9 through 11 discuss the XIL library's

image processing functions—functions that would be used inside the framework. Chapters 12 through 20 explain how the XIL library enables you to compress and decompress sequences of digital images.

A chapter-by-chapter description of the book follows:

Chapter 1, "Introduction to the XIL Library," provides an overview of the XIL library functions. In addition, the chapter discusses how the XIL library relates to other Sun Microsystems™, and third-party, libraries.

Chapter 2, "Basic XIL Program," introduces programming with the XIL library by looking at a simple XIL program that reads an 8-bit grayscale image from a file and displays it in an X window.

Chapter 3, "XIL Images," discusses the different types of XIL images, what attributes XIL images have, and how images are stored in memory.

Chapter 4, "XIL Storage," describes each of the XIL image storage formats and the functions for accessing information in a storage object. In addition, the chapter discusses how to enforce storage organization.

Chapter 5, "XIL Program That Uses Tiling," describes how to write an XIL program that uses tiled memory.

Chapter 6, "Handling Input and Output," takes a systematic look at how you handle the reading and writing of images in an XIL program, including input/output (I/O) with files, displays, and other devices.

Chapter 7, "Reading Kodak PhotoCD Images," discusses the library's device handler for reading and decoding the Eastman Kodak Company's Photo CD format.

Chapter 8, "Preparing Images for Display," discusses some of the issues that arise when you need to display different types of XIL images on different types of displays.

Chapter 9, "Presentation Functions," discusses a group of functions that are useful in preparing images for display. Topics covered include dithering and color space conversion.

Chapter 10, "Error Handling," discusses the XIL library's default error handler and explains how to write and install a custom error handler.

Chapter 11, "Arithmetic, Relational, and Logical Functions," covers the XIL library's arithmetic and logical functions. These functions enable you to add two images, take the logical AND of two images, multiply an image by a constant, and so on.

Chapter 12, "Geometric Functions," discusses the XIL library's geometric functions. Included among these are functions enabling you to scale images, rotate images, and transpose images.

Chapter 13, "Miscellaneous Image Processing Functions," presents the remaining image-processing functions in the XIL library. Among other uses, these functions give you the ability to filter images, pass images through lookup tables, and dilate or erode images.

Chapter 14, "Compressed Image Sequences," discusses the compressed image sequence data structure (called a CIS) in which you store compressed image data. The chapter goes over basic CIS management operations such as creating a CIS and writing data to it. In addition the chapter discusses CIS attributes and how to recover from datastream errors.

Chapter 15, "Compressing and Decompressing Sequences of Images," illustrates compressing and decompressing image sequences by presenting two example programs: a movie maker and a movie player.

Chapter 16, "JPEG Baseline Sequential Codec," discusses how the library's JPEG baseline sequential compressor and decompressor (codec) works and the special attributes of a JPEG CIS.

Chapter 17, "JPEG Lossless Codec," explains how the JPEG lossless codec performs its job and presents information about attributes that are specific to a CIS associated with a JPEG lossless codec.

Chapter 18, "H.261 Codec," covers the XIL interface to the codec specified by the CCITT in Recommendation H.261. The chapter discusses how such a codec works and lists the CIS attributes that apply specifically to a CIS associated with an H.261 compressor or decompressor.

Chapter 19, "MPEG-1 Codec," discusses the XIL interface to the MPEG-1 codec specified by the Moving Pictures Expert Group. The chapter discusses how an MPEG-1 codec works and lists the CIS attributes that apply specifically to a CIS associated with an MPEG-1 codec.

Chapter 20, "CCITT Group 3 and Group 4 Codecs," discusses how these document image codecs work and lists the CIS attributes specific to these codecs.

Chapter 21, "Cell Codec," deals with the Cell codec. The chapter briefly explains how the Cell codec works, discusses attributes that are specific to a Cell codec, and explains how to call optimized routines to play back Cell-encoded movies.

Chapter 22, "CellB Codec," discusses the library's CellB codec, which was derived from the Cell codec for use in videoconferencing applications. The chapter explains how the CellB codec works and the special attributes of a CellB CIS.

Chapter 23, "Acceleration in XIL Programs," explains how the XIL runtime system defers the execution of functions called in XIL programs as long as possible so that it can replace certain sequences of functions with optimized routines.

Appendix A, "Optimizations and Molecules For XIL Version 1.3," identifies the optimizations provided with the current release of the library. Molecules are optimized routines that the library can execute in lieu of executing a predefined sequence of functions from the API. The appendix includes additional optimizations for some of the molecules.

Appendix B, "XIL Error Messages," provides a list of XIL error messages. For each message, the appendix specifies an error ID and a list of functions that can generate the error.

Appendix C, "XIL-XGL Interoperability," explains how a single program can use both XIL and XGL™ functions to process an image.

Appendix D, "Cell and CellB Bytestream Definitions," presents the information about Cell and CellB bytestreams that you would need to implement a Cell or CellB codec.

Appendix E, "Bibliography," lists some books and articles to consult for further information on such subjects as image processing operations, JPEG compression, dithering, and color models.

The book also contains a glossary of terms from the fields of image processing and digital video.

Converting an RGB Image to an Indexed-Color Image and a Colormap

The `display` program prepares a true-color image to be shown on an indexed-color display by performing an ordered dither on the source image. The general procedure the example employs is to create a colorcube and a dither mask and then to call the `xil_ordered_dither()` function. After this operation, the program has a single-band version of the source image and a colorcube that defines the RGB values to be associated with each value in the indexed-color image. Before displaying the indexed-color image, the example creates a virtual X colormap and writes the values in the XIL colorcube to the X colormap.

Note – For a more detailed explanation of ordered dithering, see "Dithering an Image" on page 161.

The code the example uses to perform the ordered dither is shown below.

```
...
XilImage image              = NULL;
XilImage display_image      = NULL;
XilImage retained_image     = NULL;
...
XilLookup colorcube         = NULL;
...
XilDitherMask dithermask;
...
retained_image = xil_create(state, width, height, 1, XIL_BYTE);
colorcube = xil_lookup_get_by_name(state, "cc496");
dithermask = xil_dithermask_get_by_name(state, "dm443");
...
set_colormap(display_image, xdisplay, xwindow, colorcube);
xil_ordered_dither(image, retained_image, colorcube,
   dithermask);
...
```

The `cc496` colorcube and the `dm443` dither mask are default objects the library makes available when it is initialized. The colorcube is appropriate for dithering an RGB image to 216 colors (the indexes range from 38 to 253), and `dm443` is a 4-by-4 dither mask.

Note – These objects could also have been created with the `xil_colorcube_create()` and `xil_dithermask_create()` functions.

Before the indexed-color image can be displayed, the color values in the colorcube `colorcube` must be stored in color cells 38 to 253 in the application's X colormap. This task is handled by the `set_colormap()` function. Note that the colormap data that is being loaded into the X colormap is taken from the lookup table that was used as the colorcube for the dithering operation.

The XIL library also includes two other types of dithering operations that you can use in preparing a true-color image to be shown on an indexed-color display. The functions that perform these dithering operations are called `xil_nearest_color()` and `xil_error_diffusion()`. For further information about these functions, see "xil_nearest_color()" on page 164 and "xil_error_diffusion()" on page 170.

Converting a 24-Bit Image to a 1-Bit Image

The example uses a two-step process to convert an RGB image to a 1-bit image. The first step is to convert the 24-bit source image to an 8-bit grayscale image by extracting luminance information from the source image. Using the XIL library, you perform this task by converting the source image from the RGB color space to the Y color space. The destination image for this color-space conversion must be a single-band image.

The code `display` used to perform this color-space conversion is as follows:

```
XilImage image              = NULL;
XilImage bit_image          = NULL;
...
XilColorspace rgb_cspace;
XilColorspace ylinear_cspace;
...
bit_image = xil_create(state, width, height, 1, XIL_BYTE);
...
rgb_cspace = xil_colorspace_get_by_name(state,"rgblinear");
xil_set_colorspace(image, rgb_cspace);
ylinear_cspace = xil_colorspace_get_by_name(state, "ylinear");
xil_set_colorspace(bit_image, ylinear_cspace);
xil_color_convert(image, bit_image);
...
```

The second step in the process is to dither the 8-bit image to a 1-bit image using either the `xil_ordered_dither()` or `xil_error_diffusion()` function. If execution speed is your primary concern, use the ordered-dither function. To obtain the best quality image, use the error-diffusion function. For more information about these functions, see "xil_ordered_dither()" on page 174 and "xil_error_diffusion()" on page 170.

The `display` example dithers the image using `xil_error_diffusion()`.

```
...
XilKernel distribution;
...
XilLookup       colorcube   = NULL;
int             multipliers = -1;
unsigned int    dimensions  = 2;
...
retained_image = xil_create(state, width, height, 1, XIL_BIT);
distribution = xil_kernel_get_by_name(state, "floyd-steinberg");
colorcube = xil_colorcube_create(state, XIL_BIT, XIL_BYTE, 1, 0,
    multipliers, dimensions);
xil_error_diffusion(bit_image, retained_image, colorcube,
    distribution);
...
```

3. **Cast the values in the rescaled image to be of type `XIL_BYTE`.** Although you have rescaled your image so that its values fall in the range 0 to 255, those values are still 16-bit signed values. Before copying your image to the display, you must use the `xil_cast()` function to create an `XIL_BYTE` version of the image. For more information about `xil_cast()`, see "Casting an Image From One Data Type to Another," below.

Here's another case in which you may need to rescale an image before displaying it. Suppose you want to display an 8-bit grayscale image in an 8-bit `GrayScale` window, but you do not want to use the currently installed X colormap in displaying it. You want to create a new virtual X colormap, store a grayscale ramp in that colormap, and have it installed when your application is active. If you write values to all 256 color cells in the virtual colormap, you're almost certainly going to see colormap flashing when the colormap is installed, so you may decide not to write values to the first 16 color cells—to write all the values needed to display your image in color cells 17 through 255. This strategy requires that you rescale the values in your image so that they fall in the range 17 to 255.

Casting an Image From One Data Type to Another

The `xil_cast()` function casts an XIL image from one data type to another. The function's prototype is shown below.

```
void xil_cast(XilImage src, XilImage dst);
```

The `src` parameter is a handle to your source image, and `dst` is a handle to a destination image. This destination must have the same width, height, and number of bands as the source image and must have the data type to which you want to cast the source image.

There are a number of instances in which you may need to use this function as you prepare an image for display. For example, you may have a single-band `XIL_SHORT` image that you want to display in an 8-bit window. To do this you need to follow these steps.

1. **Rescale the image.**
   Unless the values in your `XIL_SHORT` image already fall in the range 0 to 255, you must use the `xil_rescale()` function to map them to that range, or a subset of that range. For more information about rescaling images, see "Rescaling an Image" on page 158.

2. **Cast the `XIL_SHORT` image to an `XIL_BYTE` image.**
   Before you can display your image in an 8-bit window, you must cast the 16-bit values in the source image to 8-bit values, as shown in this code fragment.

```
XilImage short_image, byte_image;
unsigned int width, height, nbands; /* Dimensions of images */

byte_image = xil_create(state, width, height, nbands,
    XIL_BYTE);
xil_cast(short_image, byte_image);
```

Similarly, if you have an `XIL_BIT` image that you want to display in an 8-bit window, you must cast the source image to an `XIL_BYTE` image before displaying it. In this cast, the values 0 and 1 in the `XIL_BIT` image are cast to indices 0 and 1 in the `XIL_BYTE` image. If you want different indices, convert the image by passing it through a lookup table rather than by casting its data type. For information about lookup tables, see "Passing an Image Through a Lookup Table" on page 271.

Note – When casting the image so you can display it, you may want to use a display image as the destination image for the cast. However, if you intend to use the converted image again, you can cast the source image to an interim destination image, then use `xil_copy()` to copy the interim image to the display.

Dithering an Image

The XIL library provides several functions you can use to prepare images for display by dithering them. Before looking at these functions, though, this section explains what it means to dither an image in an XIL application.

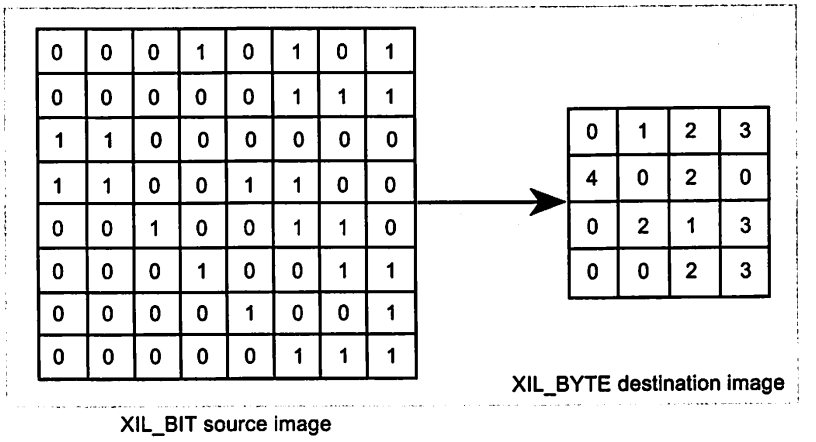

Figure 12-5 Subsampling Bit Images

If the scaling factors require a fractional block of pixels in the source to determine the destination pixel values, the block size is rounded up. For example, if a 2.2-by-2.2 block of pixels would be required to determine pixel values in the destination, a 3-by-3 block is used, resulting in 10 possible gray levels and therefore 10 colormap indexes whose values are 0 through 9.

The result of this type of operation is much clearer than the image obtained by scaling down a 1-bit image using `xil_subsample_adaptive()` or `xil_scale()`.

Rotating Images

The XIL library's rotation function is called `xil_rotate()`. This function's prototype is shown below.

```
void xil_rotate(XilImage src, XilImage dst, char *interpolation,
    float angle);
```

EXHIBIT N

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cor·re·late (kôr'ə-lāt', kŏr'-) *v.* **-lat·ed, -lat·ing, -lates.** —*tr.* **1.** To put or bring into causal, complementary, parallel, or reciprocal relation. **2.** To establish or demonstrate as having a correlation: *correlated drug abuse and crime.* —*intr.* To be related by a correlation. —*adj.* (-lĭt, -lāt'). Related by a correlation, esp. having corresponding characteristics. —*n.* (-lĭt, -lāt'). Either of two correlate entities; correlative. [Back-formation from CORRELATION.]

cor·re·la·tion (kôr'ə-lā'shən, kŏr'-) *n.* **1.** A causal, complementary, parallel, or reciprocal relationship, esp. a structural, functional, or qualitative correspondence between two comparable entities: *a correlation between recession and unemployment.* **2.** *Statistics.* **a.** The simultaneous increase or decrease in value of two numerically valued random variables: *the positive correlation between cigarette smoking and the incidence of lung cancer.* **b.** The simultaneous increase in the value of one and decrease in the value of the other of two numerically valued random variables: *the negative correlation between age and normal vision.* **3. a.** The act of correlating. **b.** The condition of being correlated. [Med. Lat. *correlatio* : Lat. *com-*, together + *relatio*, relation < *referre*, to carry back.] —**cor're·la'tion·al** *adj.*

correlation coefficient *n.* A measure of the interdependence of two random variables that ranges in value from −1 to +1, indicating perfect negative correlation at −1, absence of correlation at 0, and perfect positive correlation at +1.

cor·rel·a·tive (kə-rĕl'ə-tĭv) *adj.* **1.** Related; corresponding. **2.** Indicating a reciprocal or complementary relationship: *a correlative conjunction.* —*n.* **1.** Either of two correlative entities; correlate. **2.** *Gram.* A correlative word or expression. —**cor·rel'a·tive·ly** *adv.*

cor·re·spond (kôr'ĭ-spŏnd', kŏr'-) *intr.v.* **-spond·ed, -spond·ing, -sponds. 1.** To be in agreement, harmony, or conformity; be consistent or compatible: *Our goals corresponded.* **2.** To be similar, parallel, equivalent, or equal in character, quantity, origin, structure, or function: *English "navel" corresponds to Greek "omphalos."* **3.** To communicate by letter, usually over a period of time. [OFr. *correspondre* < Med. Lat. *correspondĕre* : Lat. *com-*, together + *respondēre*, to respond.]

cor·re·spon·dence (kôr'ĭ-spŏn'dəns, kŏr'-) *n.* **1.** The act, fact, or state of agreeing or conforming. **2.** Similarity or analogy. **3. a.** Communication by the exchange of letters. **b.** The letters written or received.

correspondence principle *n.* The principle that predictions of quantum theory approach those of classical physics in the limit of large quantum numbers.

correspondence school *n.* A school that offers instruction by mail, sending lessons and examinations to a student.

cor·re·spon·den·cy (kôr'ĭ-spŏn'dən-sē, kŏr'-) *n.* Correspondence.

cor·re·spon·dent (kôr'ĭ-spŏn'dənt, kŏr'-) *n.* **1.** One who communicates by means of letters. **2.** Someone employed by a newspaper or magazine to supply news or articles: *a foreign correspondent.* **3.** A person or firm having regular business relations with another, esp. at a distance. **4.** Something that corresponds; correlative. —*adj.* Corresponding. —**cor're·spon'dent·ly** *adv.*

correspondent banking *n.* A system of banking under which large banks perform various services for smaller banks in return for balances that the small banks keep with them.

cor·re·spond·ing (kôr'ĭ-spŏn'dĭng, kŏr'-) *adj.* **1.** Agreeing or conforming, as in degree or kind; consistent. **2.** Analogous or equivalent. —**cor're·spond'ing·ly** *adv.*

cor·re·spon·sive (kôr'ĭ-spŏn'sĭv, kŏr'-) *adj.* Jointly responsive. —**cor're·spon'sive·ly** *adv.*

cor·ri·da (kô-rē'də, -thə) *n.* A bullfight. [Sp. < *correr*, to run < Lat. *currere.*]

cor·ri·dor (kôr'ĭ-dər, -dôr', kŏr'-) *n.* **1.** A narrow hallway, passageway, or gallery, often with rooms or apartments opening onto it. **2. a.** A tract of land forming a passageway, as one that allows an inland country access to the sea through another country. **b.** A lane for the passage of aircraft. [OFr. < Oltal. *corridore* < *correre*, to run < Lat. *currere.*]

cor·rie (kôr'ē, kŏr'ē) *n. Scot.* A round hollow in a hillside; cirque. [Sc. Gael. *coire.*]

cor·ri·gen·dum (kôr'ə-jĕn'dəm, kŏr'-) *n., pl.* **-da** (-də). **1.** An error to be corrected, esp. a printer's error. **2. corrigenda.** A list of errors in a book with their corrections. [Lat., neuter gerund. of *corrigere*, to correct.]

cor·ri·gi·ble (kôr'ĭ-jə-bəl, kŏr'-) *adj.* Capable of being corrected, reformed, or improved. [ME < OFr. < Med. Lat. *corrigibilis* < Lat. *corrigere*, to correct.] —**cor'ri·gi·bil'i·ty** *n.* —**cor'ri·gi·bly** *adv.*

cor·ri·val (kə-rī'vəl, kō-) *n.* A rival or opponent. —*adj.* Rival or opposing. [OFr. or < Lat. *corrivalis* : *com-* (intensive) + *rivalis*, rival.] —**cor·rī'val·ry** (-rē) *n.*

cor·rob·o·rant (kə-rŏb'ər-ənt) *adj. Archaic.* Producing or stimulating physical vigor. Used of a medicine.

cor·rob·o·rate (kə-rŏb'ə-rāt') *tr.v.* **-rat·ed, -rat·ing, -rates.** To support or confirm by new evidence; attest the truth or accuracy of. [Lat. *corroborare, corroborat-* : *com-* (intensive) + *roborare*, to strengthen < *robur*, strength.] —**cor·rob'o·ra'tion** *n.* —**cor·rob'o·ra'tive** (-ə-rā'tĭv, -ər'ə-tĭv) *adj.* —**cor·rob'o·ra'tor** *n.* —**cor·rob'o·ra·to'ry** (-ər-ə-tôr'ē, -tōr'ē) *adj.*

cor·rob·o·ree (kə-rŏb'ə-rē) *n. Austral.* **1.** An aboriginal dance festival held at night to celebrate tribal victories or other events. **2.** A large or noisy celebration. [< a native word in Australia.]

cor·rode (kə-rōd') *v.* **-rod·ed, -rod·ing, -rodes.** —*tr.* **1.** To dissolve or wear away gradually, esp. by chemical action: *acid corroding metal.* **2.** To impair steadily; deteriorate. —*intr.* To be eaten or worn away; become corroded. [ME *corroden* < Lat. *corrodere*, to gnaw away : *com-* (intensive) + *rodere*, to gnaw.] —**cor·rod'i·ble** or **cor·ro'si·ble** (-rō'sə-bəl) *adj.*

cor·ro·sion (kə-rō'zhən) *n.* **1.** The act or process of corroding. **2.** A substance, such as rust, resulting from corrosion. **3.** The condition produced by corrosion. [ME *corasioun*, corrosion of tissue < OFr. *corrosion* < LLat. *corrosio*, the act of gnawing < Lat. *corrodere*, to gnaw away. —see CORRODE.]

cor·ro·sive (kə-rō'sĭv, -zĭv) *adj.* **1. a.** Capable of producing corrosion. **b.** Inclined to produce corrosion. **2.** Spiteful, malicious, or malevolent: *corrosive criticism.* —*n.* A corrosive substance. —**cor·ro'sive·ly** *adv.* —**cor·ro'sive·ness** *n.*

corrosive sublimate *n.* Mercuric chloride.

cor·ru·gate (kôr'ə-gāt', kŏr'-) *v.* **-gat·ed, -gat·ing, -gates.** —*tr.* To shape into folds or parallel and alternating ridges and grooves. —*intr.* To become corrugated. [Lat. *corrugare, corrugat-*, to wrinkle up : *com-* (intensive) + *rugare*, to wrinkle < *ruga*, wrinkle.] —**cor'ru·ga'tor**, **cor'ru·gat'ed** (-gā'tĭd) *adj.*

corrugated iron *n.* A structural sheet iron, usually galvanized, shaped in parallel furrows and ridges for rigidity.

cor·ru·ga·tion (kôr'ə-gā'shən, kŏr'-) *n.* **1.** The act of corrugating. **2.** The state or process of being corrugated. **3.** A groove or ridge on a corrugated surface.

cor·rupt (kə-rŭpt') *adj.* **1.** Marked by immorality and perversion; depraved. **2.** Marked by venality and dishonesty: *a corrupt mayor.* **3.** Decaying; putrid. **4.** Containing errors or alterations, as a text: *a corrupt translation.* —*v.* **-rupt·ed, -rupt·ing, -rupts.** —*tr.* **1.** To destroy or subvert the honesty or integrity of. **2.** To ruin morally; pervert. **3.** To taint; contaminate. **4.** To cause to become rotten; spoil. **5.** To change the original form of (a text, for example). —*intr.* To become corrupt. [ME < Lat. *corruptus*, p.part. of *corrumpere*, to destroy : *com-*, together + *rumpere*, to break.] —**cor·rupt'er, cor·rup'tor** *n.* —**cor·rup'tive** *adj.* —**cor·rupt'ly** *adv.* —**cor·rupt'ness** *n.*

cor·rupt·i·ble (kə-rŭp'tə-bəl) *adj.* Capable of being corrupted, as by bribery or depravity. —**cor·rupt'i·bil'i·ty, cor·rupt'i·ble·ness** *n.* —**cor·rupt'i·bly** *adv.*

cor·rup·tion (kə-rŭp'shən) *n.* **1.** The act or result of corrupting. **2.** The state of being corrupt. **3.** *Archaic.* Something that corrupts. **4.** Decay; rot.

cor·rup·tion·ist (kə-rŭp'shə-nĭst) *n.* One who defends or practices corruption.

cor·sage (kôr-säzh', -säj') *n.* **1.** A small bouquet of flowers worn by a woman at the shoulder or waist or on the wrist. **2.** The bodice or waist of a dress. [ME, torso < OFr. < *cors*, body < Lat. *corpus.*]

cor·sair (kôr'sâr') *n.* **1.** A privateer, esp. along the Barbary Coast. **2.** A swift pirate ship, often operating with official sanction. **3.** A pirate. [OFr. *corsaire* < OProv. *corsari* < Oltal. *corsaro* < Med. Lat. *cursarius* < *cursus*, plunder < Lat. *cursus*, course. —see COURSE.]

corse (kôrs) *n. Archaic.* A corpse. [ME *cors* < OFr. < Lat. *corpus.*]

corse·let (kôr'slĭt) *n.* **1.** Also **cors·let.** Body armor, esp. a breastplate. **2.** (kôr'sə-lĕt'). A light corset with few or no stays. [OFr. *corselet*, dim. of *corset*, dim. of *cors*, body < Lat. *corpus.*]

cor·set (kôr'sĭt) *n.* **1.** A close-fitting undergarment, often reinforced by stays, worn to support and shape the waistline, hips, and breasts. **2.** A medieval outer garment, esp. a laced jacket or bodice. —*tr.v.* **-set·ed, -set·ing, -sets.** To enclose in or as if in a corset. [ME, bodice < OFr., dim. of *cors*, body < Lat. *corpus.*]

cor·se·tière (kôr'sĭ-tyâr', -tĭr') *n.* A maker, fitter, or seller of corsets. [Fr. < *corset*, corset < OFr.]

cors·let (kôr'slĭt) *n.* Variant of **corselet** (sense 1).

cor·tege also **cor·tège** (kôr-tĕzh') *n.* **1.** A train of attendants, as of a distinguished person; retinue. **2. a.** A ceremonial procession. **b.** A funeral procession. [Fr. *cortège* < Oltal. *corteggio* < *corteggiare*, to pay honor < *corte*, court < Lat. *cohors*, throng.]

cor·tex (kôr'tĕks') *n., pl.* **-ti·ces** (-tĭ-sēz') or **-tex·es. 1.** *Anat.* **a.** The outer layer of an organ or part, as of the kidney, cerebrum, or cerebellum. **b.** The firm outer layer that comprises most of the adrenal gland. **2.** *Bot.* **a.** A layer of tissue in roots and stems lying between the epidermis and the vascular tissue. **b.** An external layer such as bark or rind. [Lat., bark.]

cortic- *pref.* Variant of **cortico-.**

cor·ti·cal (kôr'tĭ-kəl) *adj.* **1.** Of, pertaining to, or consisting of cortex. **2.** Of, pertaining to, associated with, or depending on the cerebral cortex. [NLat. *corticalis* < Lat. *cortex*, bark.] —**cor'ti·cal·ly** *adv.*

cor·ti·cate (kôr'tĭ-kĭt, -kāt') also **cor·ti·cat·ed** (-kā'tĭd) *adj.*

cortege
Funeral cortege

cor·re·late (kôr'ə-lāt', kŏr'-) *v.* **-lat·ed, -lat·ing, -lates.** —*tr.* **1.** To put or bring into causal, complementary, parallel, or reciprocal relation. **2.** To establish or demonstrate as having a correlation: *correlated drug abuse and crime.* —*intr.* To be related by a correlation. —*adj.* (-lĭt, -lāt'). Related by a correlation, esp. having corresponding characteristics. —*n.* (-lĭt, -lāt'). Either of two correlate entities; correlative. [Back-formation from CORRELATION.]

cor·re·la·tion (kôr'ə-lā'shən, kŏr'-) *n.* **1.** A causal, complementary, parallel, or reciprocal relationship, esp. a structural, functional, or qualitative correspondence between two comparable entities: *a correlation between recession and unemployment.* **2.** *Statistics.* **a.** The simultaneous increase or decrease in value of two numerically valued random variables: *the positive correlation between cigarette smoking and the incidence of lung cancer.* **b.** The simultaneous increase in the value of one and decrease in the value of the other of two numerically valued random variables: *the negative correlation between age and normal vision.* **3. a.** The act of correlating. **b.** The condition of being correlated. [Med. Lat. *correlatio* : Lat. *com-*, together + *relatio*, relation < *referre*, to carry back.] —**cor're·la'tion·al** *adj.*

correlation coefficient *n.* A measure of the interdependence of two random variables that ranges in value from −1 to +1, indicating perfect negative correlation at −1, absence of correlation at 0, and perfect positive correlation at +1.

cor·rel·a·tive (kə-rĕl'ə-tĭv) *adj.* **1.** Related; corresponding. **2.** Indicating a reciprocal or complementary relationship: *a correlative conjunction.* —*n.* **1.** Either of two correlative entities; correlate. **2.** *Gram.* A correlative word or expression. —**cor·rel'a·tive·ly** *adv.*

cor·re·spond (kôr'ĭ-spŏnd', kŏr'-) *intr.v.* **-spond·ed, -spond·ing, -sponds. 1.** To be in agreement, harmony, or conformity; be consistent or compatible: *Our goals corresponded.* **2.** To be similar, parallel, equivalent, or equal in character, quantity, origin, structure, or function: *English "navel" corresponds to Greek "omphalos."* **3.** To communicate by letter, usually over a period of time. [OFr. *correspondre* < Med. Lat. *correspondĕre* : Lat. *com-*, together + *respondēre*, to respond.]

cor·re·spon·dence (kôr'ĭ-spŏn'dəns, kŏr'-) *n.* **1.** The act, fact, or state of agreeing or conforming. **2.** Similarity or analogy. **3. a.** Communication by the exchange of letters. **b.** The letters written or received.

correspondence principle *n.* The principle that predictions of quantum theory approach those of classical physics in the limit of large quantum numbers.

correspondence school *n.* A school that offers instruction by mail, sending lessons and examinations to a student.

cor·re·spon·den·cy (kôr'ĭ-spŏn'dən-sē, kŏr'-) *n.* Correspondence.

cor·re·spon·dent (kôr'ĭ-spŏn'dənt, kŏr'-) *n.* **1.** One who communicates by means of letters. **2.** Someone employed by a newspaper or magazine to supply news or articles: *a foreign correspondent.* **3.** A person or firm having regular business relations with another, esp. at a distance. **4.** Something that corresponds; correlative. —*adj.* Corresponding. —**cor're·spon'dent·ly** *adv.*

correspondent banking *n.* A system of banking under which large banks perform various services for smaller banks in return for balances that the small banks keep with them.

cor·re·spond·ing (kôr'ĭ-spŏn'dĭng, kŏr'-) *adj.* **1.** Agreeing or conforming, as in degree or kind; consistent. **2.** Analogous or equivalent. —**cor're·spond'ing·ly** *adv.*

cor·re·spon·sive (kôr'ĭ-spŏn'sĭv, kŏr'-) *adj.* Jointly responsive. —**cor're·spon'sive·ly** *adv.*

cor·ri·da (kô-rē'də, -thə) *n.* A bullfight. [Sp. < *correr*, to run < Lat. *currere.*]

cor·ri·dor (kôr'ĭ-dər, -dôr', kŏr'-) *n.* **1.** A narrow hallway, passageway, or gallery, often with rooms or apartments opening onto it. **2. a.** A tract of land forming a passageway, as one that allows an inland country access to the sea through another country. **b.** A lane for the passage of aircraft. [OFr. < Oltal. *corridore* < *correre*, to run < Lat. *currere.*]

cor·rie (kôr'ē, kŏr'ē) *n. Scot.* A round hollow in a hillside; cirque. [Sc. Gael. *coire.*]

cor·ri·gen·dum (kôr'ə-jĕn'dəm, kŏr'-) *n., pl.* **-da** (-də). **1.** An error to be corrected, esp. a printer's error. **2. corrigenda.** A list of errors in a book with their corrections. [Lat., neuter gerund. of *corrigere*, to correct.]

cor·ri·gi·ble (kôr'ĭ-jə-bəl, kŏr'-) *adj.* Capable of being corrected, reformed, or improved. [ME < OFr. < Med. Lat. *corrigibilis* < Lat. *corrigere*, to correct.] —**cor'ri·gi·bil'i·ty** *n.* —**cor'ri·gi·bly** *adv.*

cor·ri·val (kə-rī'vəl, kō-) *n.* A rival or opponent. —*adj.* Rival or opposing. [OFr. or < Lat. *corrivalis* : *com-* (intensive) + *rivalis*, rival.] —**cor·rī'val·ry** (-rē) *n.*

cor·rob·o·rant (kə-rŏb'ər-ənt) *adj. Archaic.* Producing or stimulating physical vigor. Used of a medicine.

cor·rob·o·rate (kə-rŏb'ə-rāt') *tr.v.* **-rat·ed, -rat·ing, -rates.** To support or confirm by new evidence; attest the truth or accuracy of. [Lat. *corroborare, corroborat-* : *com-* (intensive) + *roborare*, to strengthen < *robur*, strength.] —**cor·rob'o·ra'tion** *n.* —**cor·rob'o·ra'tive** (-ə-rā'tĭv, -ər'ə-tĭv) *adj.* —**cor·rob'o·ra'tor** *n.* —**cor·rob'o·ra·to'ry** (-ər-ə-tôr'ē, -tōr'ē) *adj.*

cor·rob·o·ree (kə-rŏb'ə-rē) *n. Austral.* **1.** An aboriginal dance festival held at night to celebrate tribal victories or other events. **2.** A large or noisy celebration. [< a native word in Australia.]

cor·rode (kə-rōd') *v.* **-rod·ed, -rod·ing, -rodes.** —*tr.* **1.** To dissolve or wear away gradually, esp. by chemical action: *acid corroding metal.* **2.** To impair steadily; deteriorate. —*intr.* To be eaten or worn away; become corroded. [ME *corroden* < Lat. *corrodere*, to gnaw away : *com-* (intensive) + *rodere*, to gnaw.] —**cor·rod'i·ble** or **cor·ro'si·ble** (-rō'sə-bəl) *adj.*

cor·ro·sion (kə-rō'zhən) *n.* **1.** The act or process of corroding. **2.** A substance, such as rust, resulting from corrosion. **3.** The condition produced by corrosion. [ME *corasioun*, corrosion of tissue < OFr. *corrosion* < LLat. *corrosio*, the act of gnawing < Lat. *corrodere*, to gnaw away. —see CORRODE.]

cor·ro·sive (kə-rō'sĭv, -zĭv) *adj.* **1. a.** Capable of producing corrosion. **b.** Inclined to produce corrosion. **2.** Spiteful, malicious, or malevolent: *corrosive criticism.* —*n.* A corrosive substance. —**cor·ro'sive·ly** *adv.* —**cor·ro'sive·ness** *n.*

corrosive sublimate *n.* Mercuric chloride.

cor·ru·gate (kôr'ə-gāt', kŏr'-) *v.* **-gat·ed, -gat·ing, -gates.** —*tr.* To shape into folds or parallel and alternating ridges and grooves. —*intr.* To become corrugated. [Lat. *corrugare, corrugat-*, to wrinkle up : *com-* (intensive) + *rugare*, to wrinkle < *ruga*, wrinkle.] —**cor'ru·ga'tor**, **cor'ru·gat'ed** (-gā'tĭd) *adj.*

corrugated iron *n.* A structural sheet iron, usually galvanized, shaped in parallel furrows and ridges for rigidity.

cor·ru·ga·tion (kôr'ə-gā'shən, kŏr'-) *n.* **1.** The act of corrugating. **2.** The state or process of being corrugated. **3.** A groove or ridge on a corrugated surface.

cor·rupt (kə-rŭpt') *adj.* **1.** Marked by immorality and perversion; depraved. **2.** Marked by venality and dishonesty: *a corrupt mayor.* **3.** Decaying; putrid. **4.** Containing errors or alterations, as a text: *a corrupt translation.* —*v.* **-rupt·ed, -rupt·ing, -rupts.** —*tr.* **1.** To destroy or subvert the honesty or integrity of. **2.** To ruin morally; pervert. **3.** To taint; contaminate. **4.** To cause to become rotten; spoil. **5.** To change the original form of (a text, for example). —*intr.* To become corrupt. [ME < Lat. *corruptus*, p.part. of *corrumpere*, to destroy : *com-*, together + *rumpere*, to break.] —**cor·rupt'er, cor·rup'tor** *n.* —**cor·rup'tive** *adj.* —**cor·rupt'ly** *adv.* —**cor·rupt'ness** *n.*

cor·rupt·i·ble (kə-rŭp'tə-bəl) *adj.* Capable of being corrupted, as by bribery or depravity. —**cor·rupt'i·bil'i·ty, cor·rupt'i·ble·ness** *n.* —**cor·rupt'i·bly** *adv.*

cor·rup·tion (kə-rŭp'shən) *n.* **1.** The act or result of corrupting. **2.** The state of being corrupt. **3.** *Archaic.* Something that corrupts. **4.** Decay; rot.

cor·rup·tion·ist (kə-rŭp'shə-nĭst) *n.* One who defends or practices corruption.

cor·sage (kôr-säzh', -säj') *n.* **1.** A small bouquet of flowers worn by a woman at the shoulder or waist or on the wrist. **2.** The bodice or waist of a dress. [ME, torso < OFr. < *cors*, body < Lat. *corpus.*]

cor·sair (kôr'sâr') *n.* **1.** A privateer, esp. along the Barbary Coast. **2.** A swift pirate ship, often operating with official sanction. **3.** A pirate. [OFr. *corsaire* < OProv. *corsari* < Oltal. *corsaro* < Med. Lat. *cursarius* < *cursus*, plunder < Lat. *cursus*, course. —see COURSE.]

corse (kôrs) *n. Archaic.* A corpse. [ME *cors* < OFr. < Lat. *corpus.*]

corse·let (kôr'slĭt) *n.* **1.** Also **cors·let.** Body armor, esp. a breastplate. **2.** (kôr'sə-lĕt'). A light corset with few or no stays. [OFr *corselet*, dim. of *corset*, dim. of *cors*, body < Lat. *corpus.*]

cor·set (kôr'sĭt) *n.* **1.** A close-fitting undergarment, often reinforced by stays, worn to support and shape the waistline, hips, and breasts. **2.** A medieval outer garment, esp. a laced jacket or bodice. —*tr.v.* **-set·ed, -set·ing, -sets.** To enclose in or as if in a corset. [ME, bodice < OFr., dim. of *cors*, body < Lat. *corpus.*]

cor·se·tière (kôr'sĭ-tyâr', -tĭr') *n.* A maker, fitter, or seller of corsets. [Fr. < *corset*, corset < OFr.]

cors·let (kôr'slĭt) *n.* Variant of **corselet** (sense 1).

cor·tege also **cor·tège** (kôr-tĕzh') *n.* **1.** A train of attendants, as of a distinguished person; retinue. **2. a.** A ceremonial procession. **b.** A funeral procession. [Fr. *cortège* < Oltal. *corteggio* < *corteggiare*, to pay honor < *corte*, court < Lat. *cohors*, throng.]

cor·tex (kôr'tĕks') *n., pl.* **-ti·ces** (-tĭ-sēz') or **-tex·es. 1.** *Anat.* **a.** The outer layer of an organ or part, as of the kidney, cerebrum, or cerebellum. **b.** The firm outer layer that comprises most of the adrenal gland. **2.** *Bot.* **a.** A layer of tissue in roots and stems lying between the epidermis and the vascular tissue. **b.** An external layer such as bark or rind. [Lat., bark.]

cortic- *pref.* Variant of **cortico-.**

cor·ti·cal (kôr'tĭ-kəl) *adj.* **1.** Of, pertaining to, or consisting of cortex. **2.** Of, pertaining to, associated with, or depending on the cerebral cortex. [NLat. *corticalis* < Lat. *cortex*, bark.] —**cor'ti·cal·ly** *adv.*

cor·ti·cate (kôr'tĭ-kĭt, -kāt') also **cor·ti·cat·ed** (-kā'tĭd) *adj.*

cortege
Funeral cortege

EXHIBIT O

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DICTIONARY corresponding

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corresponding

ADJECTIVE

Analogous or equivalent in character, form, or function; comparable.
'the corresponding Jamaican word is 'bada''

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